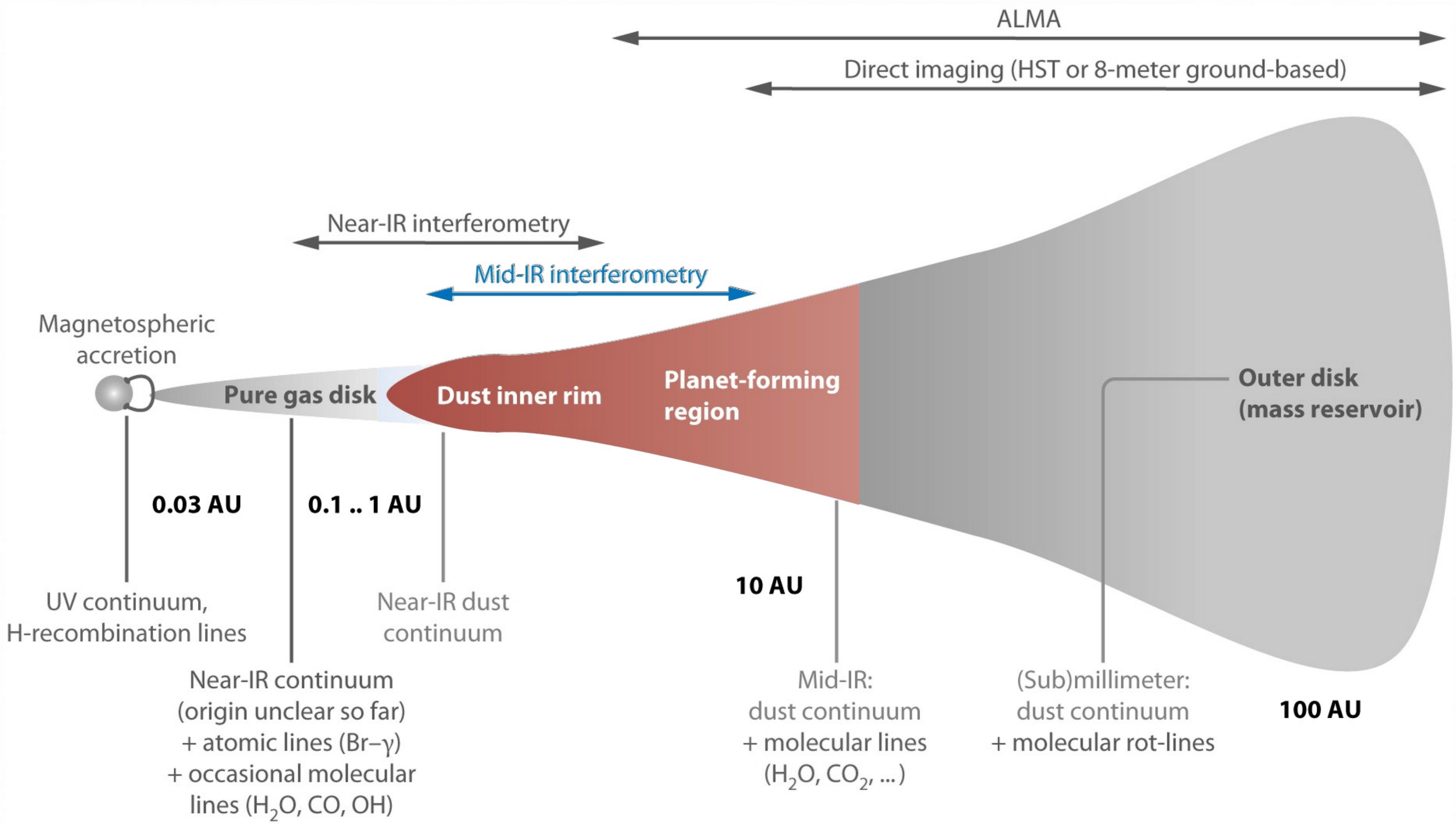
MIDI's View of Discs around Low-Mass Young Stellar Objects and their Companions

Thorsten Ratzka

Ten Years of VLTI – From First Fringes to Core Science
ESO Garching, October 24-27, 2011

Size & Structure of Circumstellar Discs

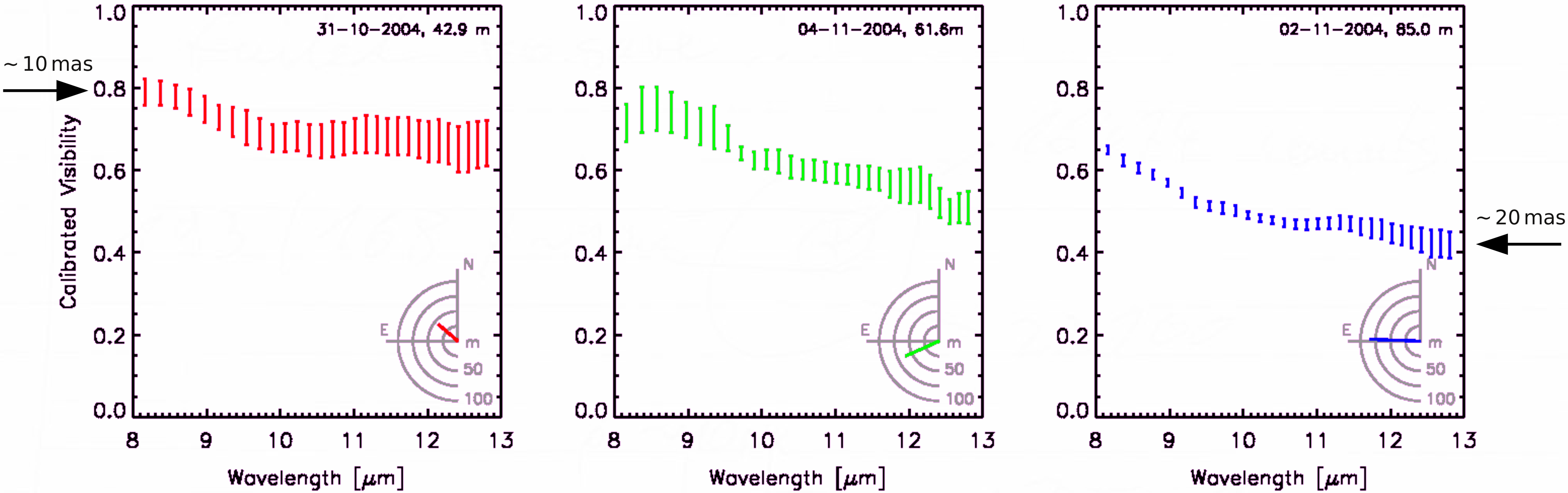
A typical circumstellar disk



100 pc	200 km	200 m	
↓	↓	↓	~ 0.01″
1 AU	1 cm	10 μm	

Dullemond & Monnier, ARAA 48, 2010

A typical circumstellar disk

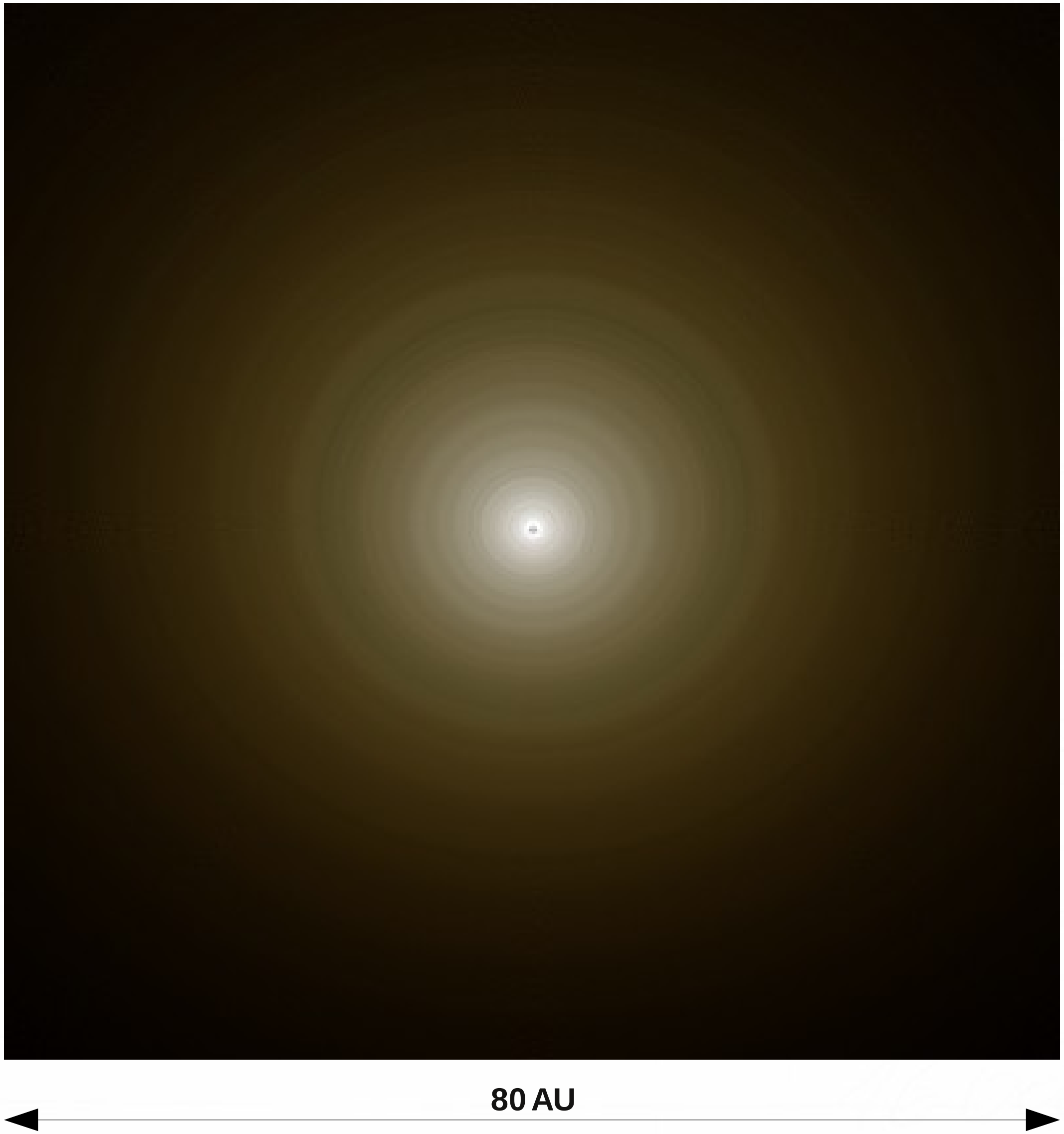


- the resolution of the interferometer decreases with wavelength
- the emitting region becomes larger due to the temperature gradient

⇒ decreasing visibilities
⇒ direct size estimates

Ratzka et al., A&A, 502, 2009

Radiative transfer model T Tau N



star

- $M_* = 2.1\,M_\odot$
- $T_* = 5250\,K$
- $L_* = 7.3\,L_\odot$
- $R_* = 3.3\,R_\odot$

disk

- $M_d = 0.04\,M_\odot$
- $r_d = 0.1\ ...\ 80\,AU$
- $i\ < 30^o$
- $h_{100} = 18\,AU$
- $\beta = 1.25$

envelope

- $c_1 = 1{\cdot}10^{-5}$
- $c_2 = -5.0$

accretion

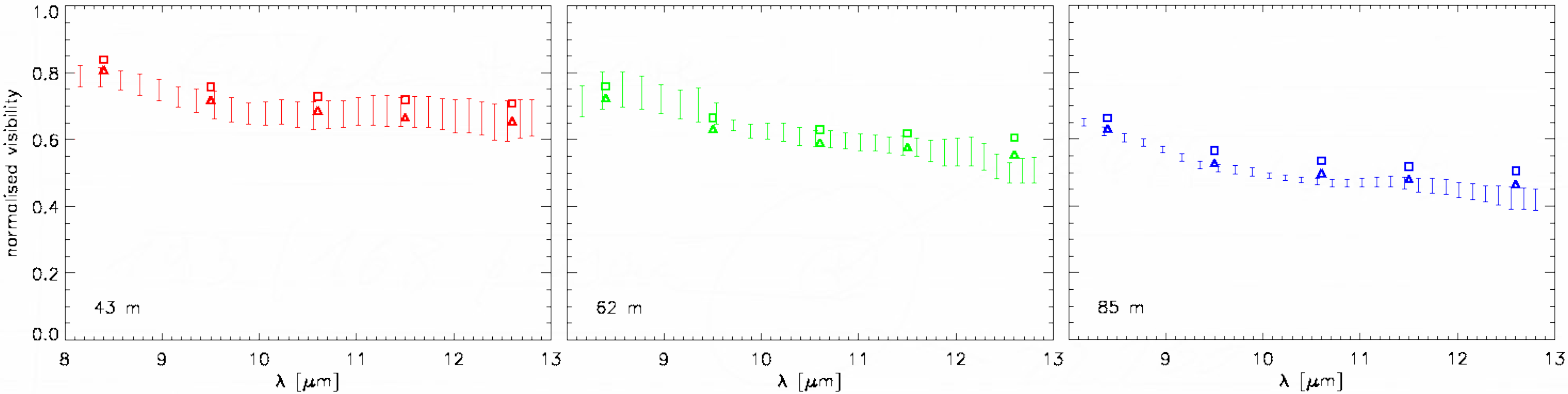
- $dM/dt = 3{\cdot}10^{-8}\,M_\odot yr^{-1}$

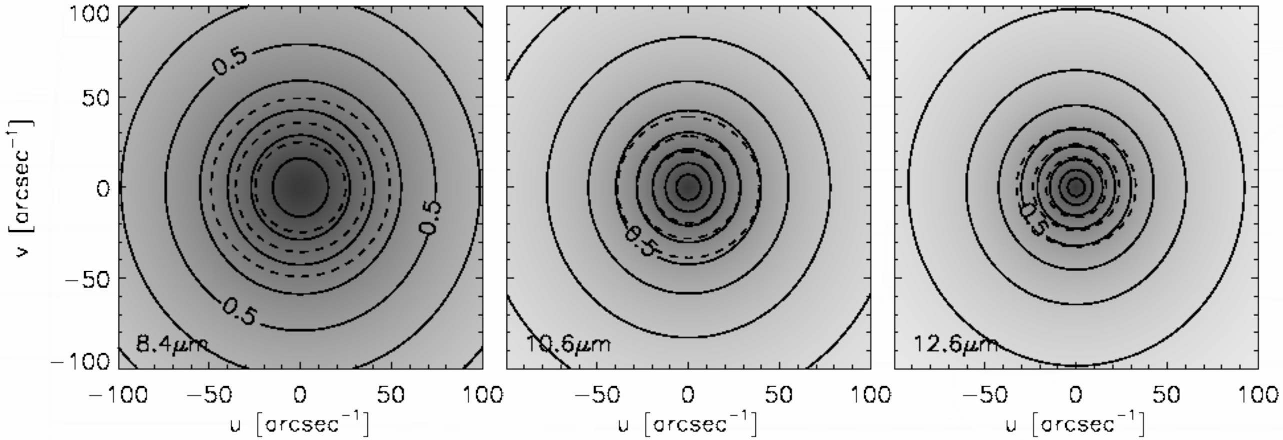
extinction (foreground)

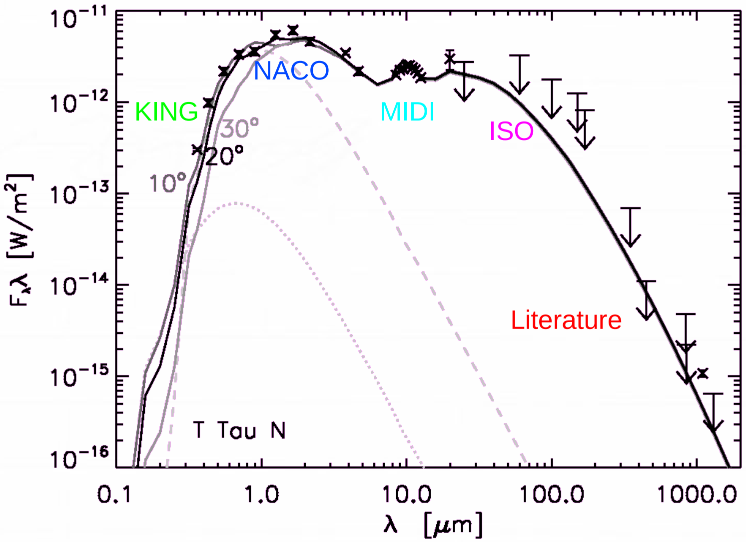
- $A_V = 1.5\,mag$

Ratzka et al., A&A, 502, 2009

Radiative transfer model T Tau N







Ratzka et al., A&A, 502, 2009

A growing “zoo” of sources ...

DR Tau	K7 ($T_* \sim 4000\,K$, $L_* \sim 1.7\,L_\odot$)	$M_* \sim 0.8\,M_\odot$	3 Myr
	$m_d \sim 0.1\,M_\odot$, $r_d \sim 0.10...90$ AU, $\beta \sim 0.75$, $h_{100} \sim 15$ AU, $i \sim 20^\circ$, $2.0 \cdot 10^{-8}\,M_\odot/yr$		
GW Ori	G0 ($T_* \sim 6000\,K$, $L_* \sim 40\,L_\odot$)	$M_* \sim 3.7\,M_\odot$	1 Myr
	$m_d \sim 1.0\,M_\odot$, $r_d \sim 0.35...360$ AU, $\beta \sim 1.10$, $h_{100} \sim 22$ AU, $i \sim 10^\circ$, $2.5 \cdot 10^{-7}\,M_\odot/yr$		
HD 72106B	A0 ($T_* \sim 9500\,K$, $L_* \sim 28\,L_\odot$)	$M_* \sim 1.8\,M_\odot$	10 Myr
	$m_d \sim 0.005\,M_\odot$, $r_d \sim 0.50...40$ AU, $\beta \sim 1.30$, $h_{100} \sim 8$ AU, $i \sim 60^\circ$, no accretion		
RU Lup	K8 ($T_* \sim 4000\,K$, $L_* \sim 1.3\,L_\odot$)	$M_* \sim 0.8\,M_\odot$	1 Myr
	$m_d \sim 0.1\,M_\odot$, $r_d \sim 0.10...100$ AU, $\beta \sim 0.90$, $h_{100} \sim 20$ AU, $i \sim 28^\circ$, $1 \cdot 10^{-8}\,M_\odot/yr$		
HBC 639	K0 ($T_* \sim 4800\,K$, $L_* \sim 8.5\,L_\odot$)	$M_* \sim 2.0\,M_\odot$	2 Myr
	$m_d \sim 0.1\,M_\odot$, $r_d \sim 0.10...120$ AU, $\beta \sim 1.00$, $h_{100} \sim 10$ AU, $i \sim 65^\circ$, no accretion		
S CrA N	K3 ($T_* \sim 4400\,K$, $L_* \sim 2.3\,L_\odot$)	$M_* \sim 1.5\,M_\odot$	3 Myr
	$m_d \sim 0.03\,M_\odot$, $r_d \sim 0.05...120$ AU, $\beta \sim 1.10$, $h_{100} \sim 9$ AU, $i \sim 10^\circ$, $4 \cdot 10^{-8}\,M_\odot/yr$		

⋮

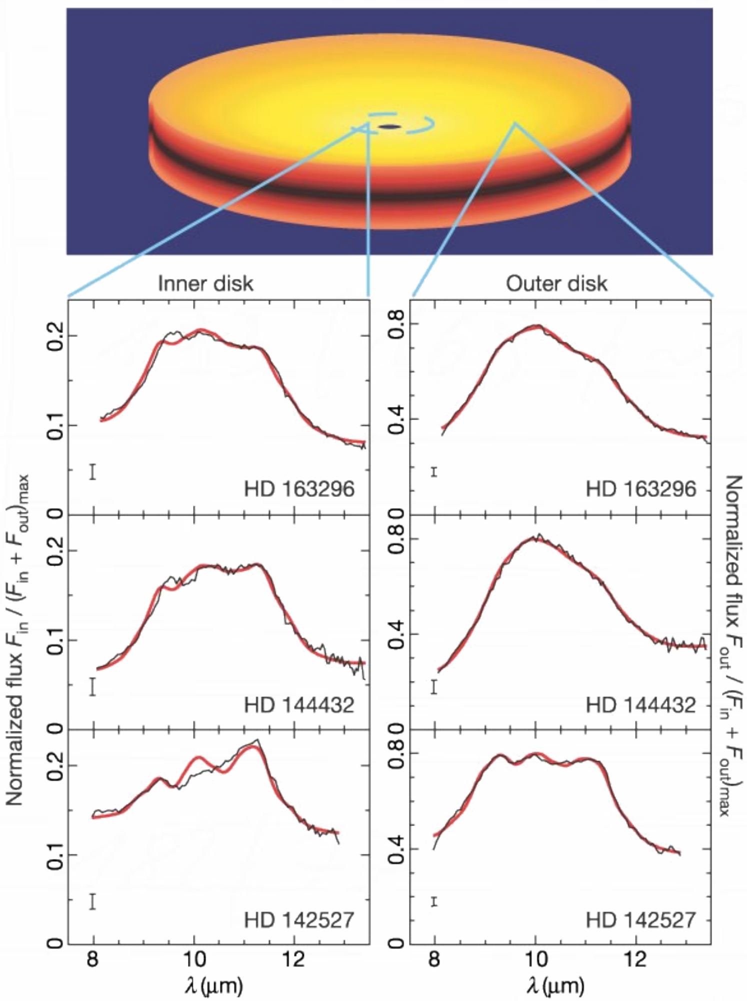
⇒ multiwavelength approach (AMBER)

Schegerer et al., A&A, 502, 2009

Schegerer et al., A&A, in prep.

Evolution of Circumstellar Discs

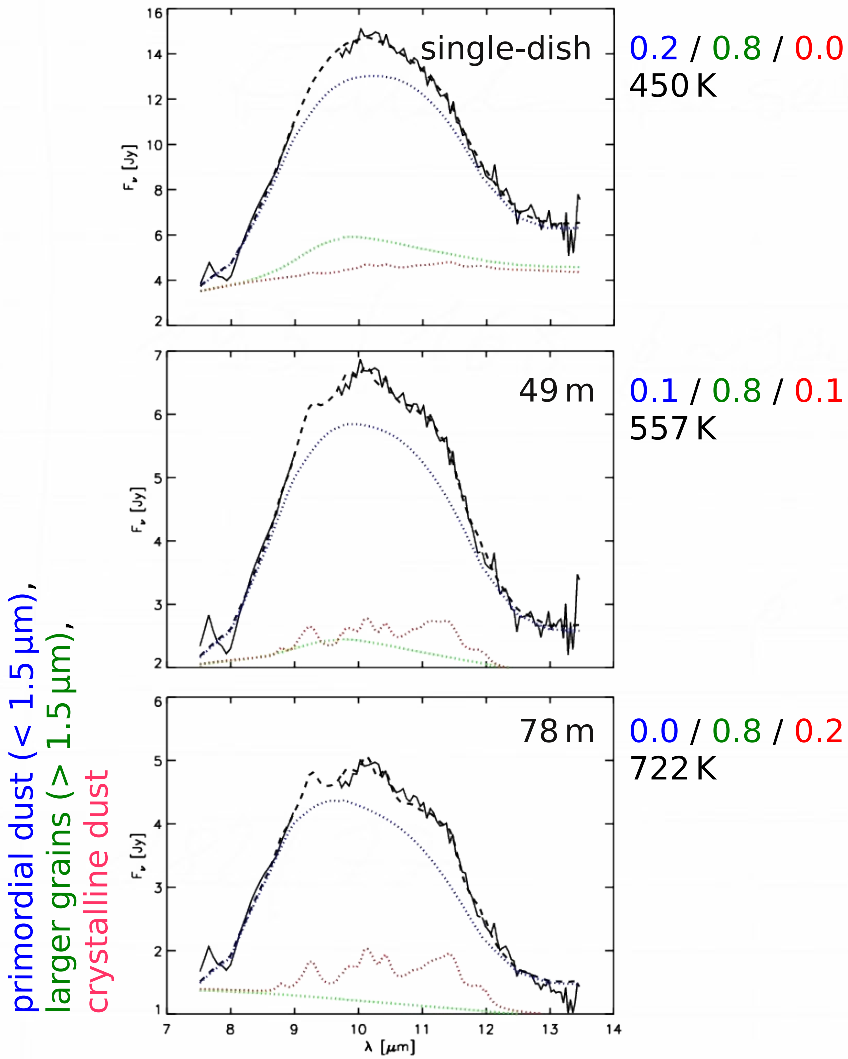
RY Tau – A case study



van Boekel et al., Nature 432, 2005

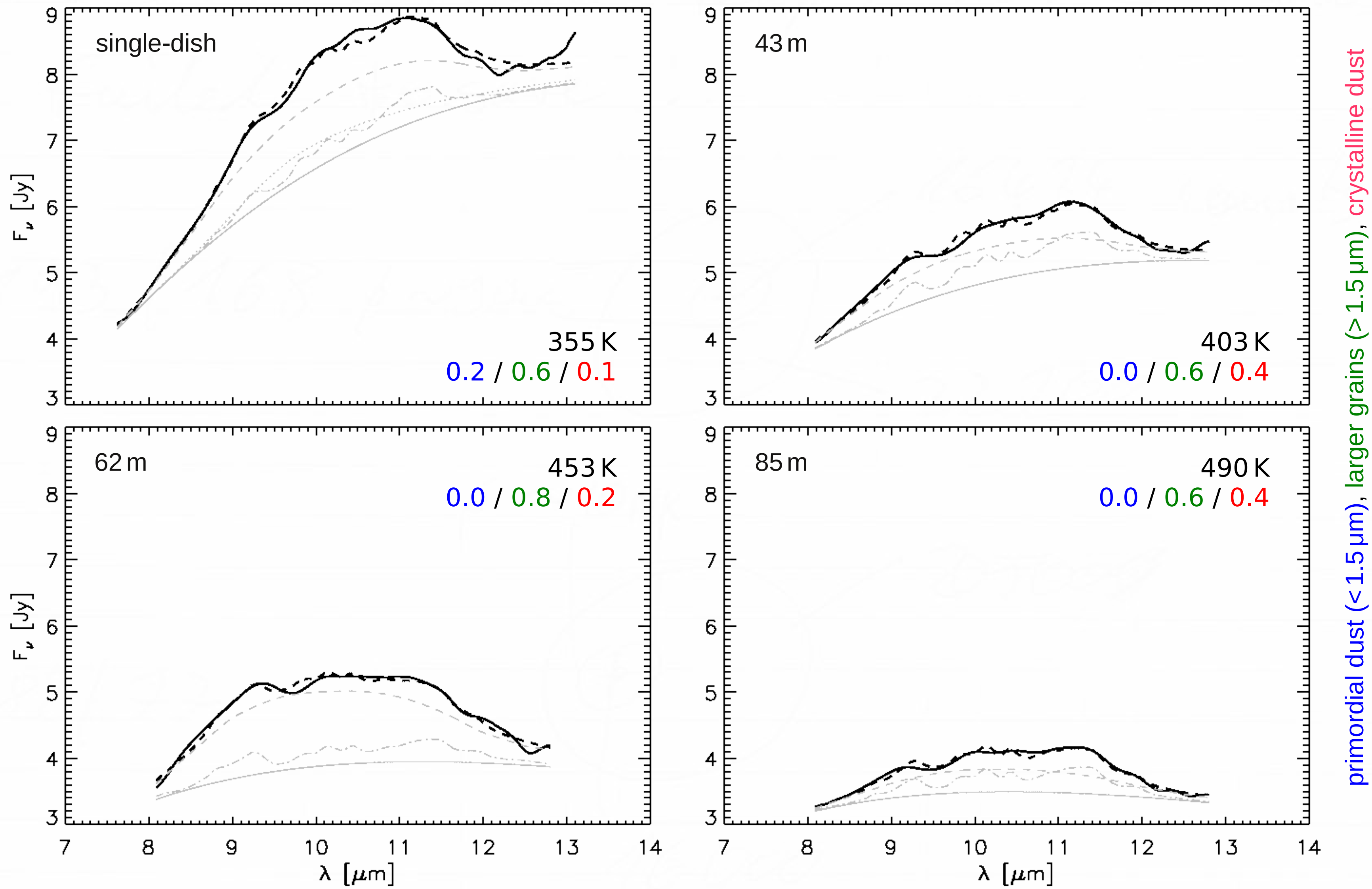
Schegerer et al., A&A, 478, 2008

RY Tau – A case study



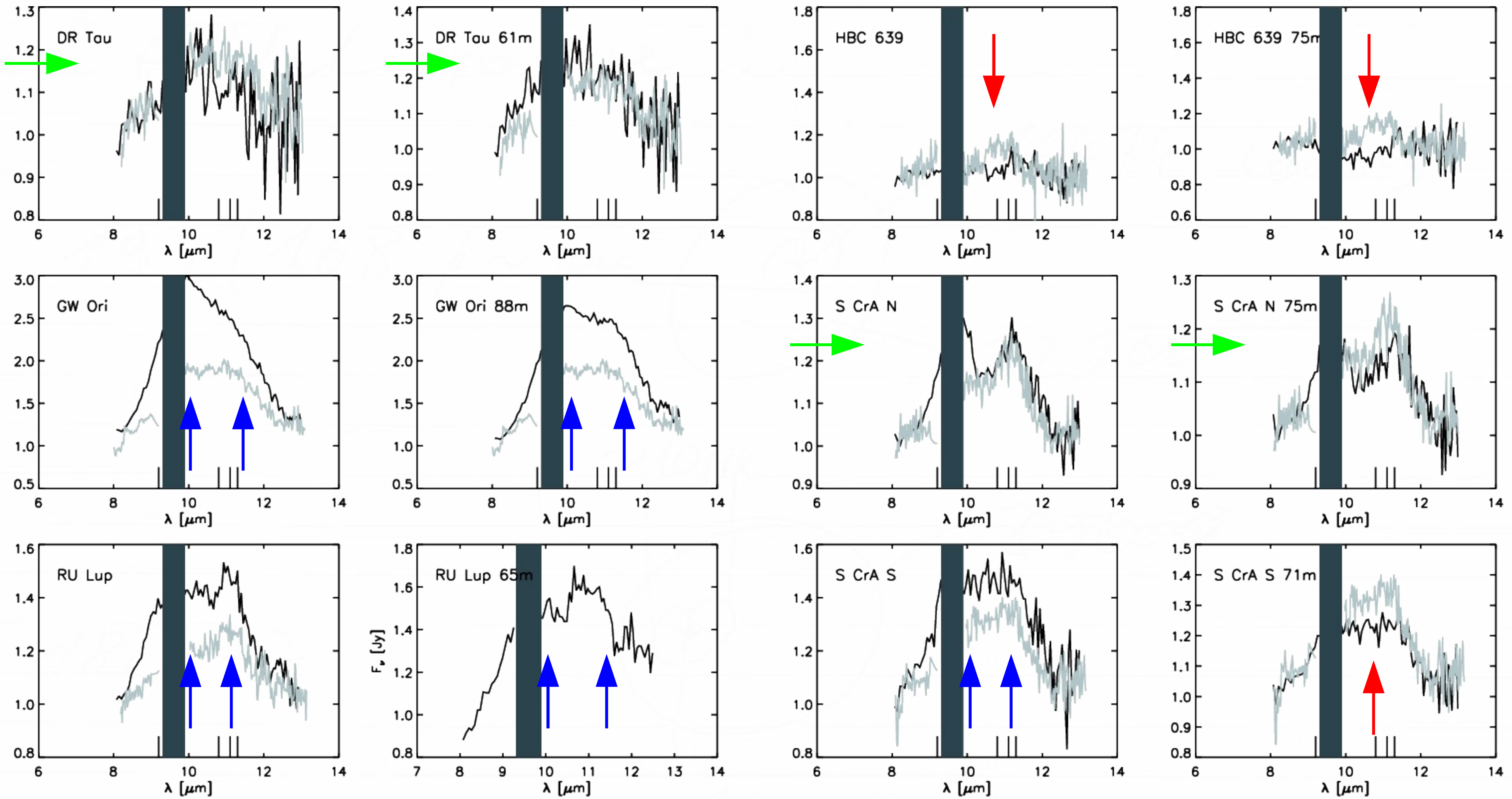
Schegerer et al., A&A, 478, 2008

Dust processing around T Tau?



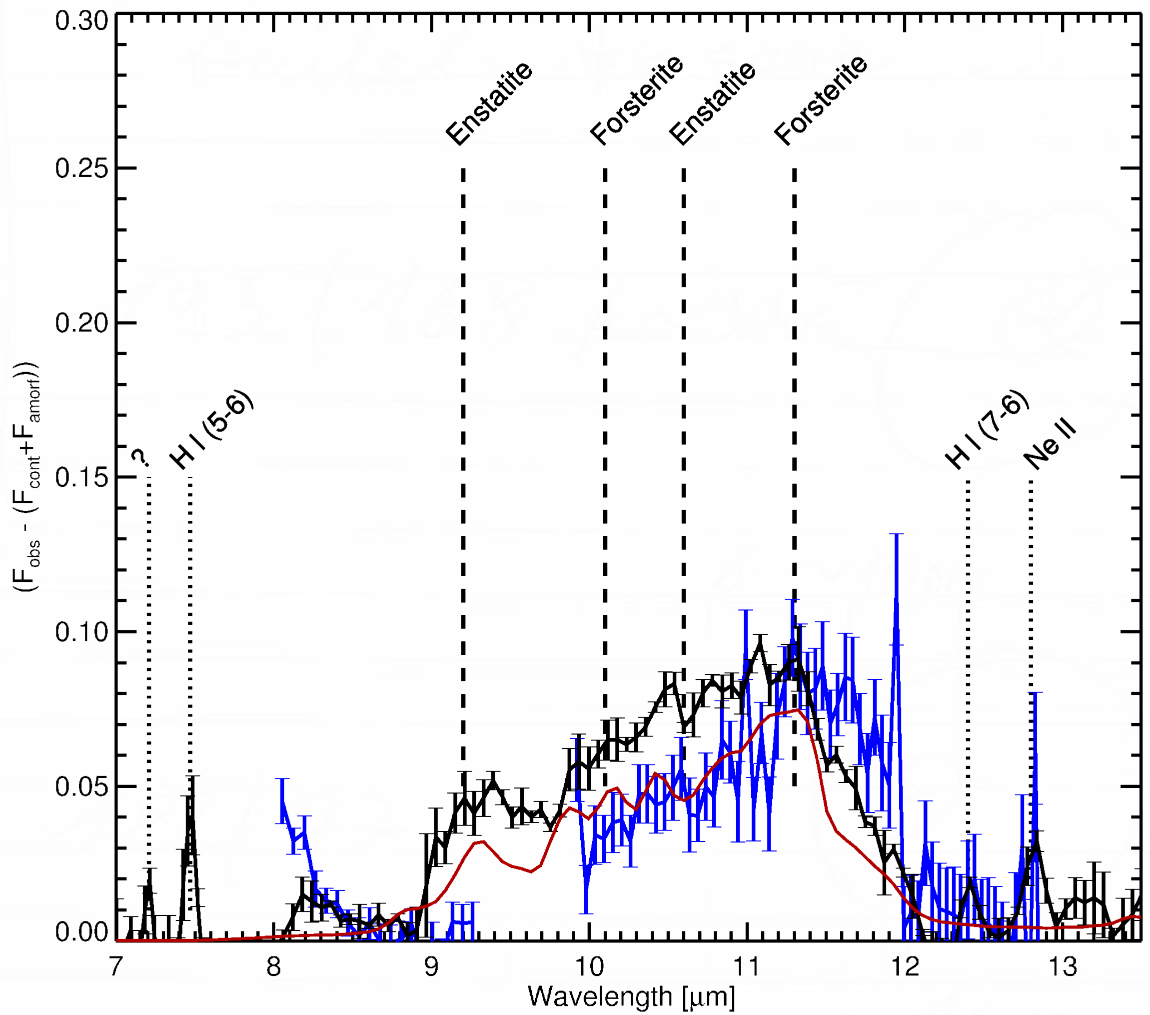
Ratzka et al., A&A, 502, 2009

Grain Growth (almost) everywhere



Schegerer et al., A&A, 502, 2009

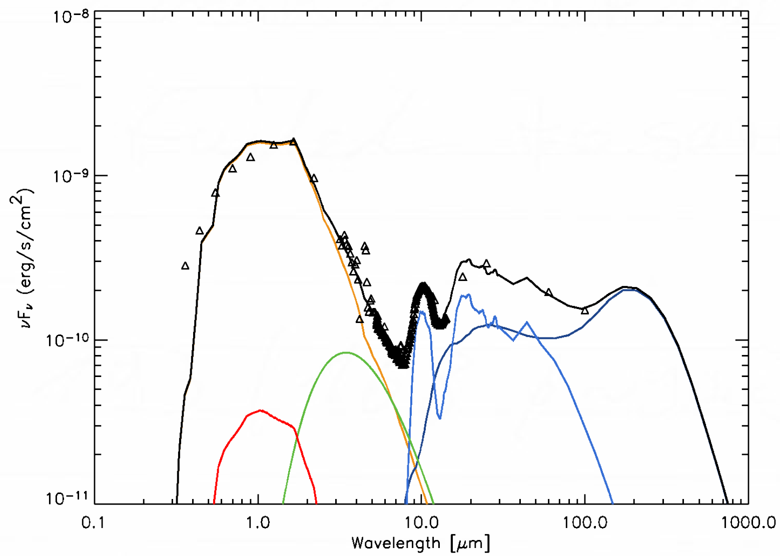
Processed Dust around TW Hya

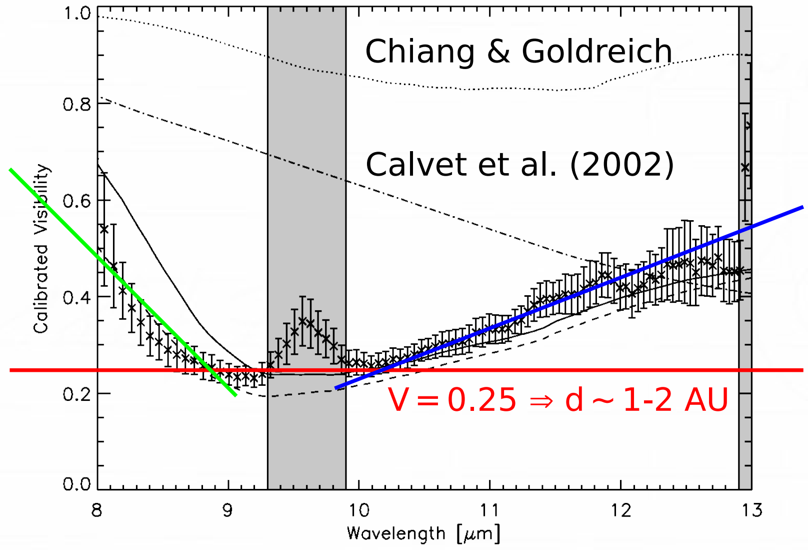


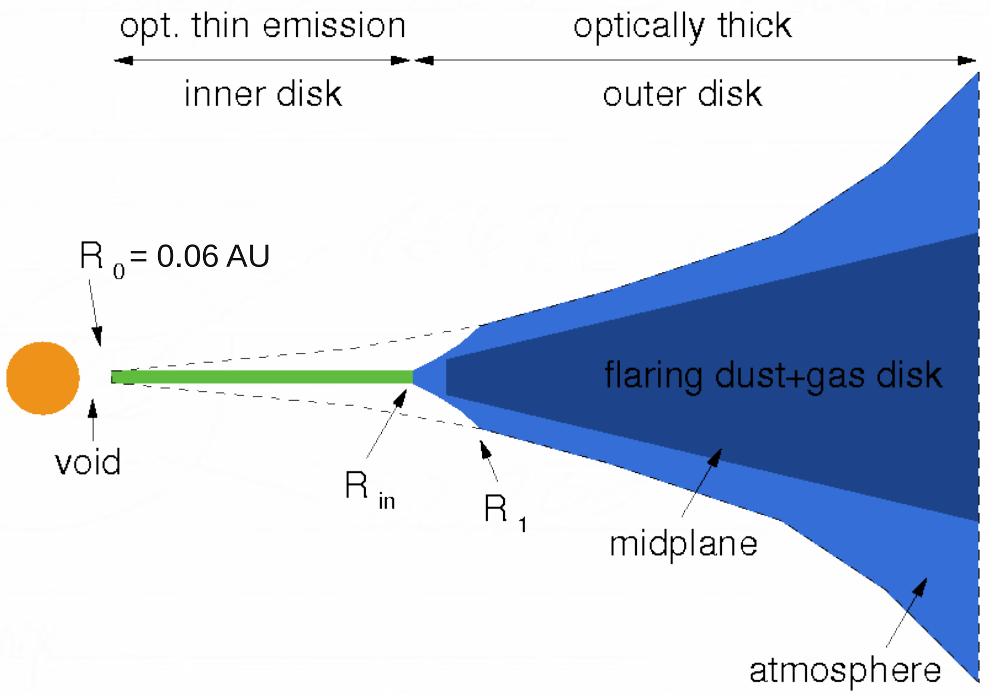
- ~ 8% of the mass is in sub-micron sized crystalline dust particles; ~83% of the mass is in sub-micron sized amorphous dust grains
- Comparison of the spectrally dispersed correlated flux with the dust model shows that most of the crystalline material is concentrated within 1 AU from the central star
- The disk of TW Hya is not well mixed

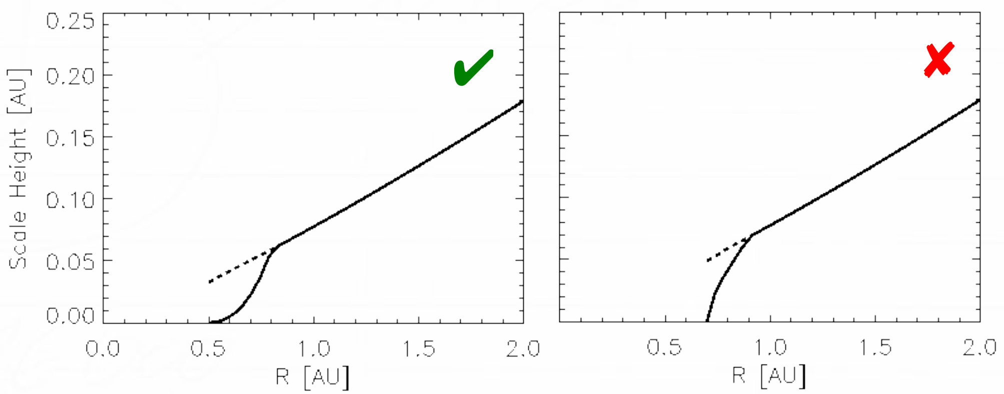
Ratzka et al., A&A, 328, 2007

The transitional disk of TW Hya



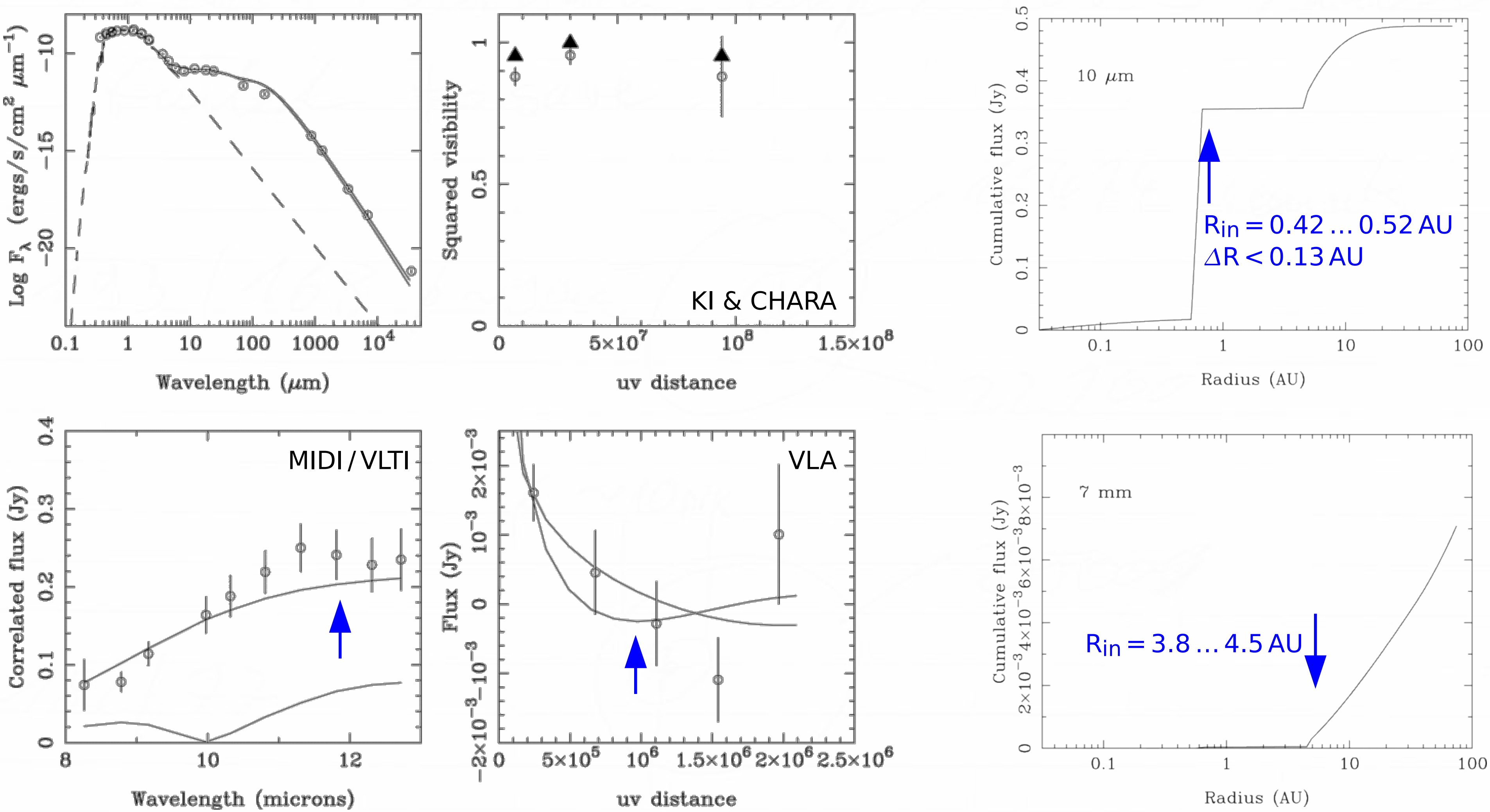






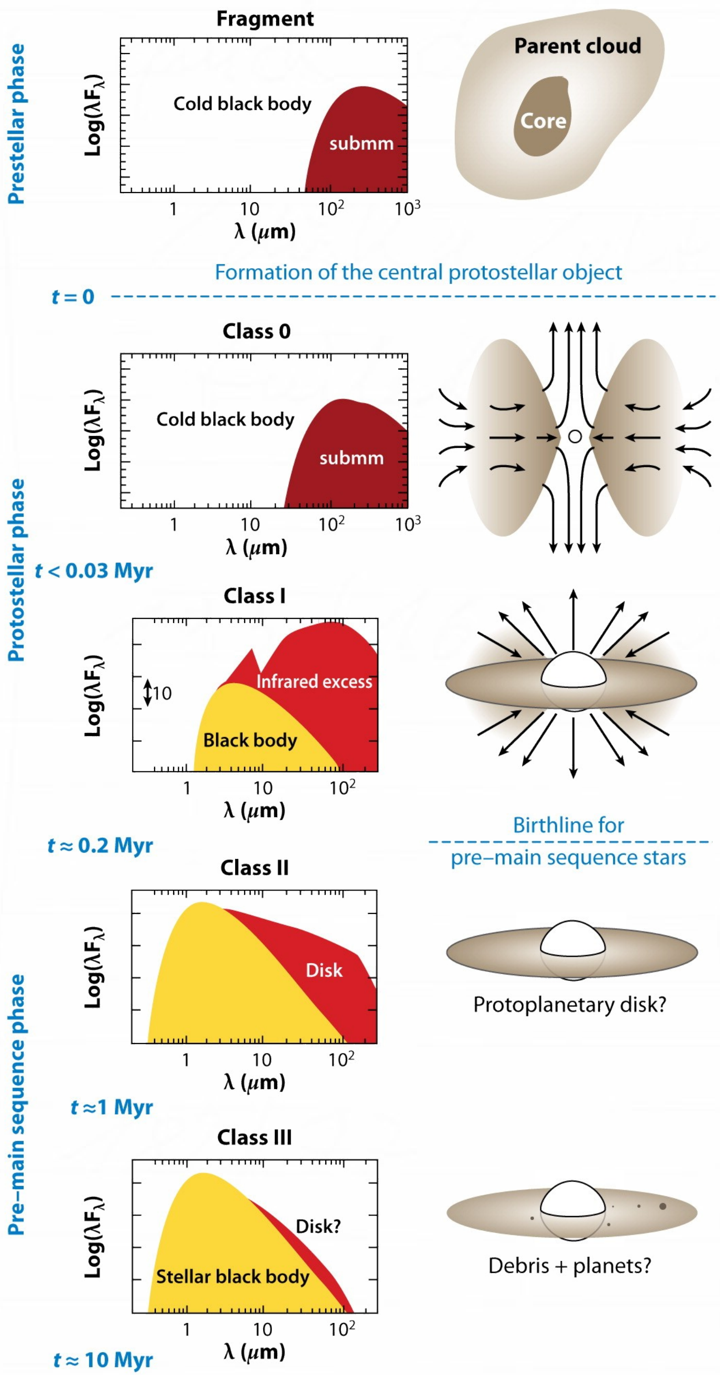
Ratzka et al., A&A, 328, 2007

The transitional disk of TW Hya

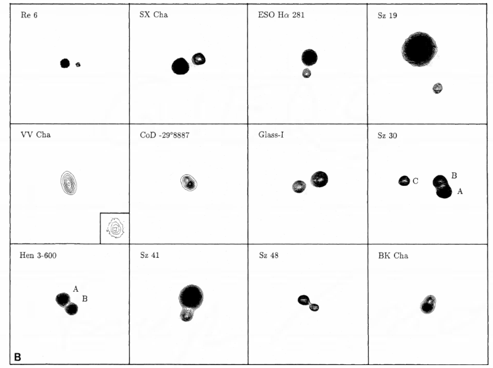


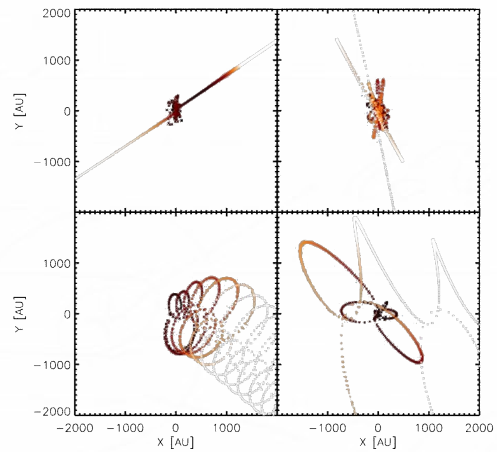
Akeson et al., ApJ, 728, 2011

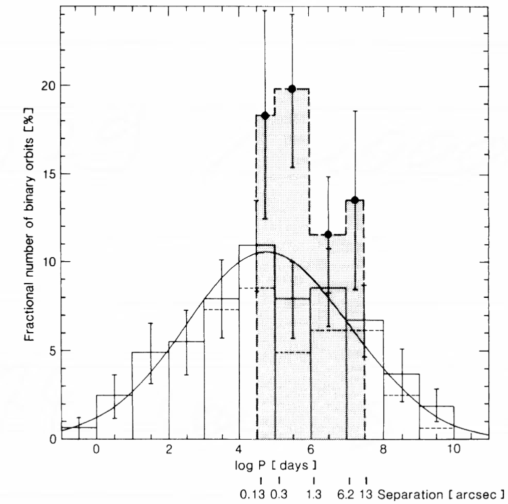
Dynamics of Circumstellar Discs



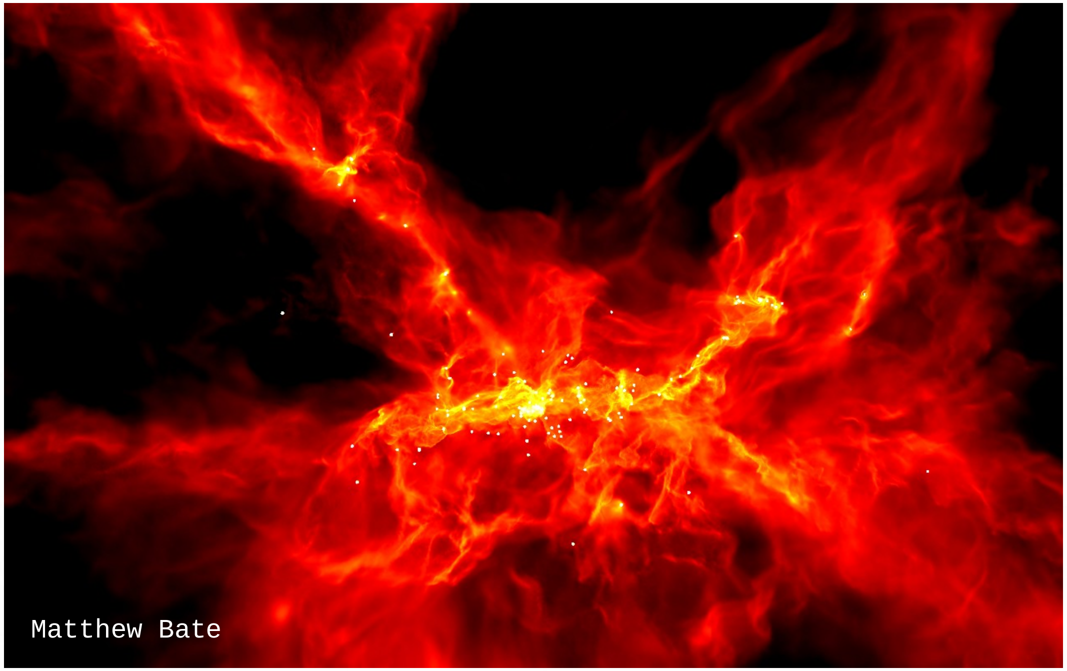
Dauphas & Chaussidon, AREPS, 39, 2011





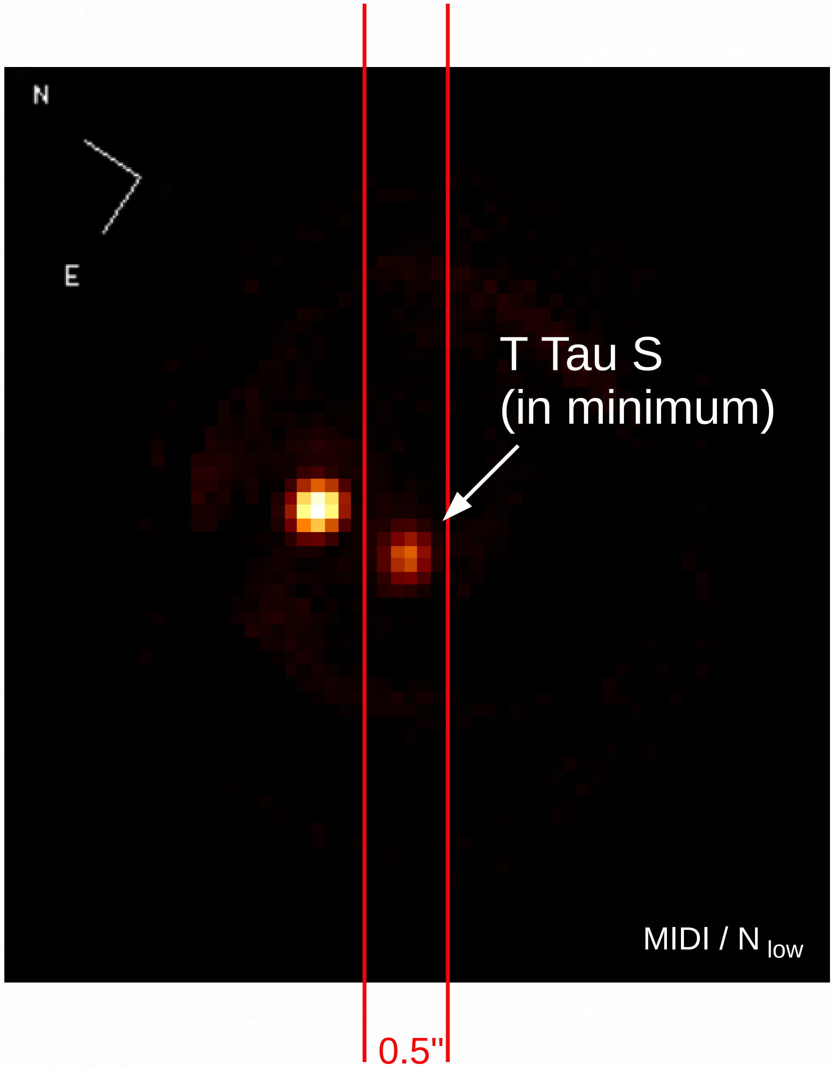


Reipurt & Zinnecker, A&A 278, 1993
Leinert et al., A&A 278, 1993
Reipurth et al., ApJ 725, 2010



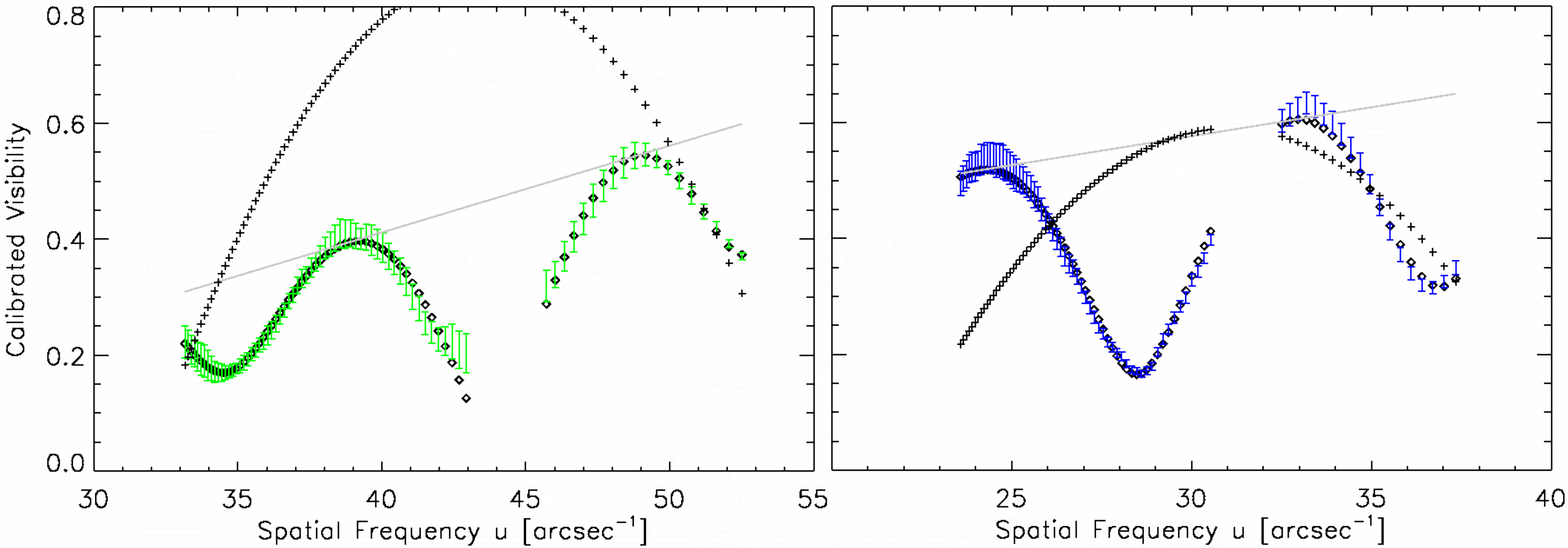
A non-prototypical prototype

T. A. Rector (University of Alaska Anchorage) &
H. Schweiker (WIYN and NOAO/AURA/NSF)



Ratzka et al., A&A, 502, 2009

Fitting the binary signal



$$V_{\mathrm{fit}}(u) = V_0(u) \cdot \frac{\sqrt{1 + f^2(u) + 2f(u)\cos\left[2\pi u s(u)\right]}}{1 + f(u)}$$

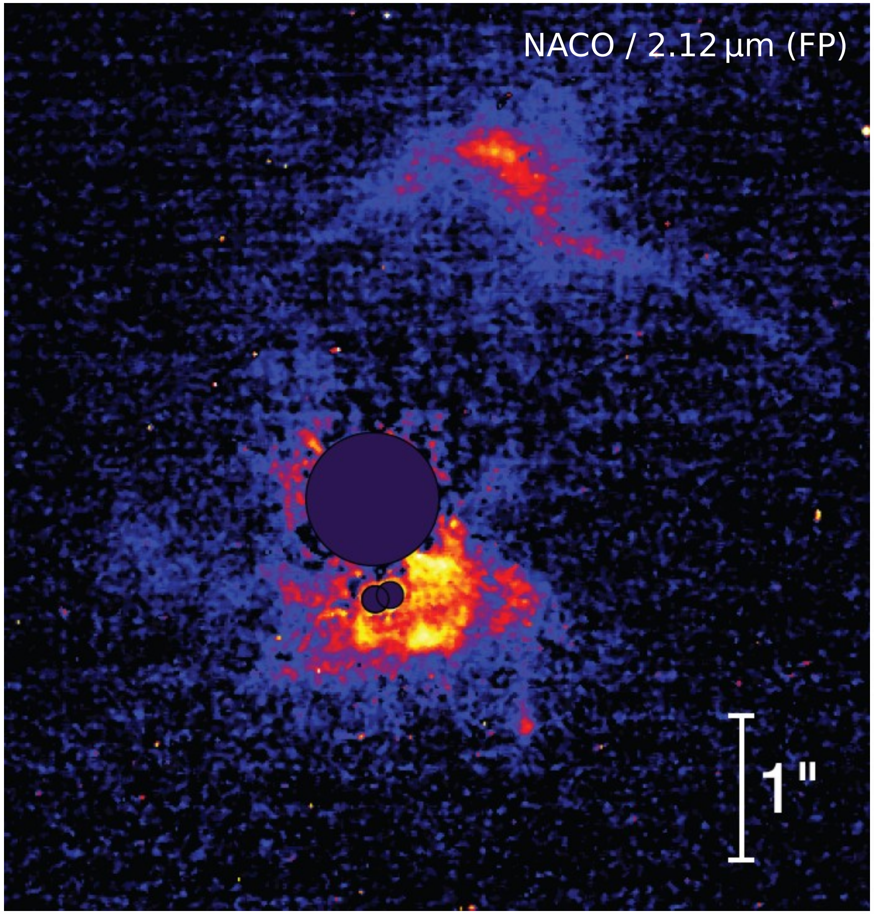
$s(u) = s_0 + s_1 u$

$V_0(u) = a_0 + a_1 u$

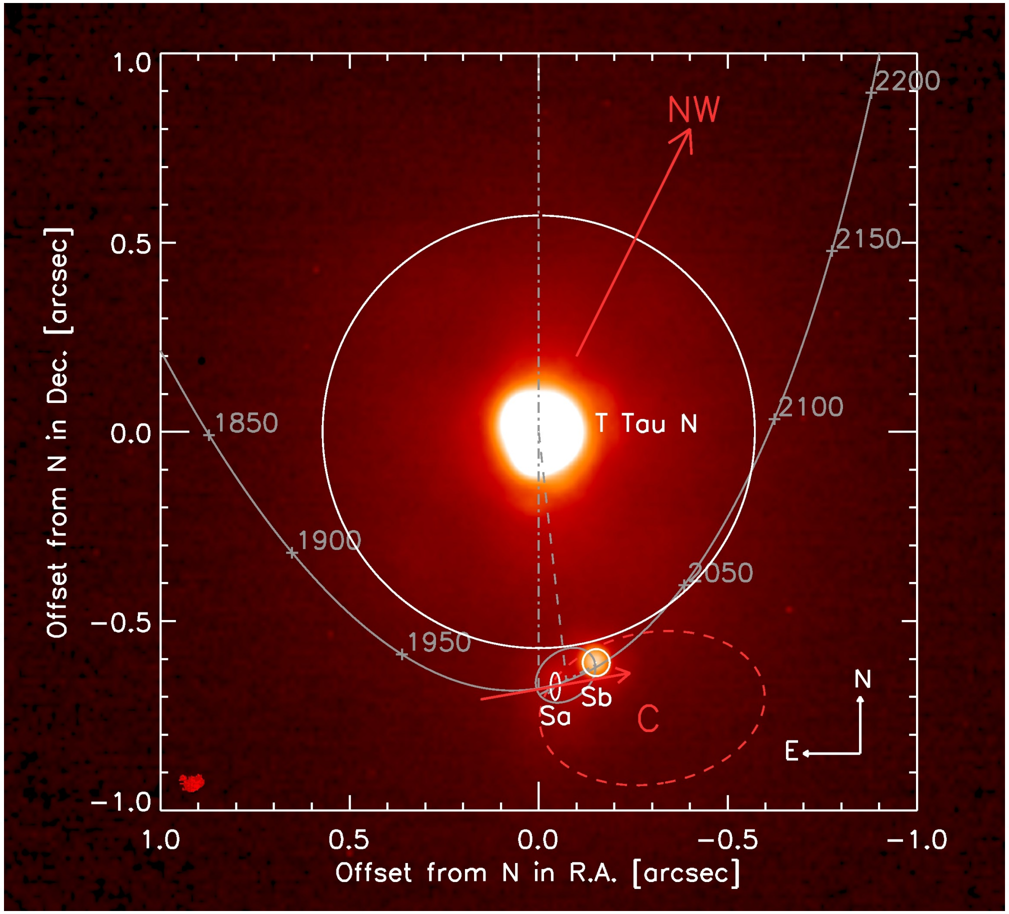
$f(u) = f_0 + f_1 u + f_2 u^2, \; f(u) < 1$

Ratzka et al., A&A, 502, 2009

Sketching the T Tau system



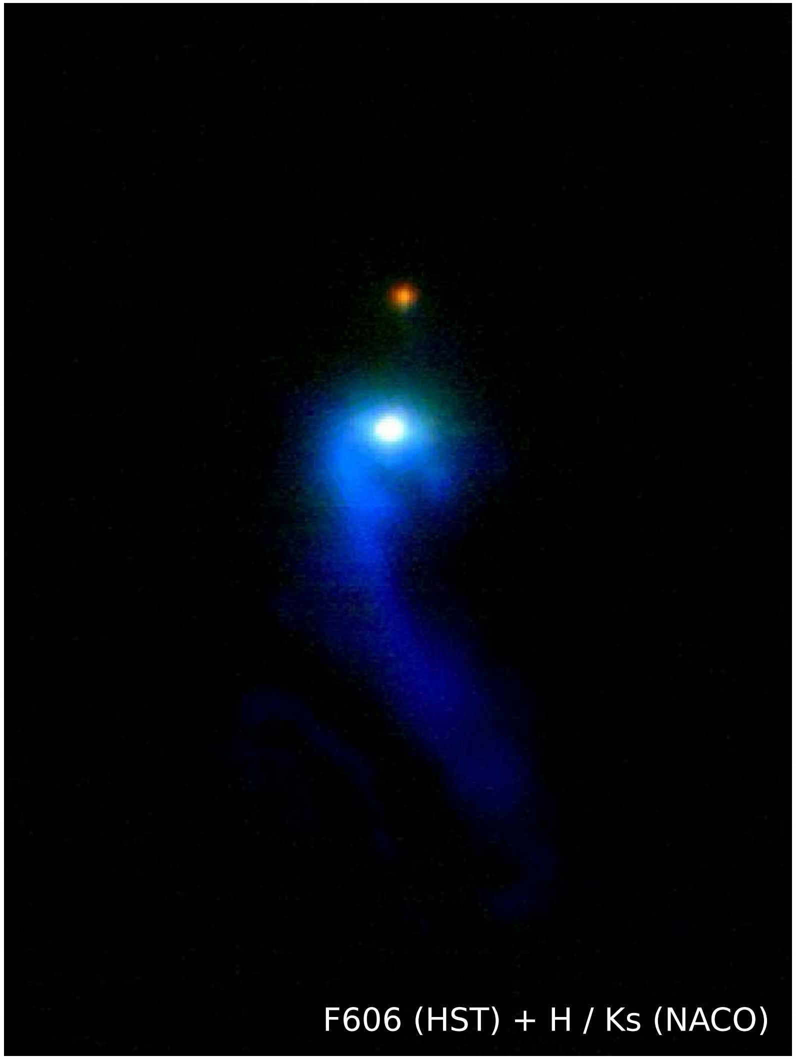
Herbst et al., AJ, 134, 359, 2007



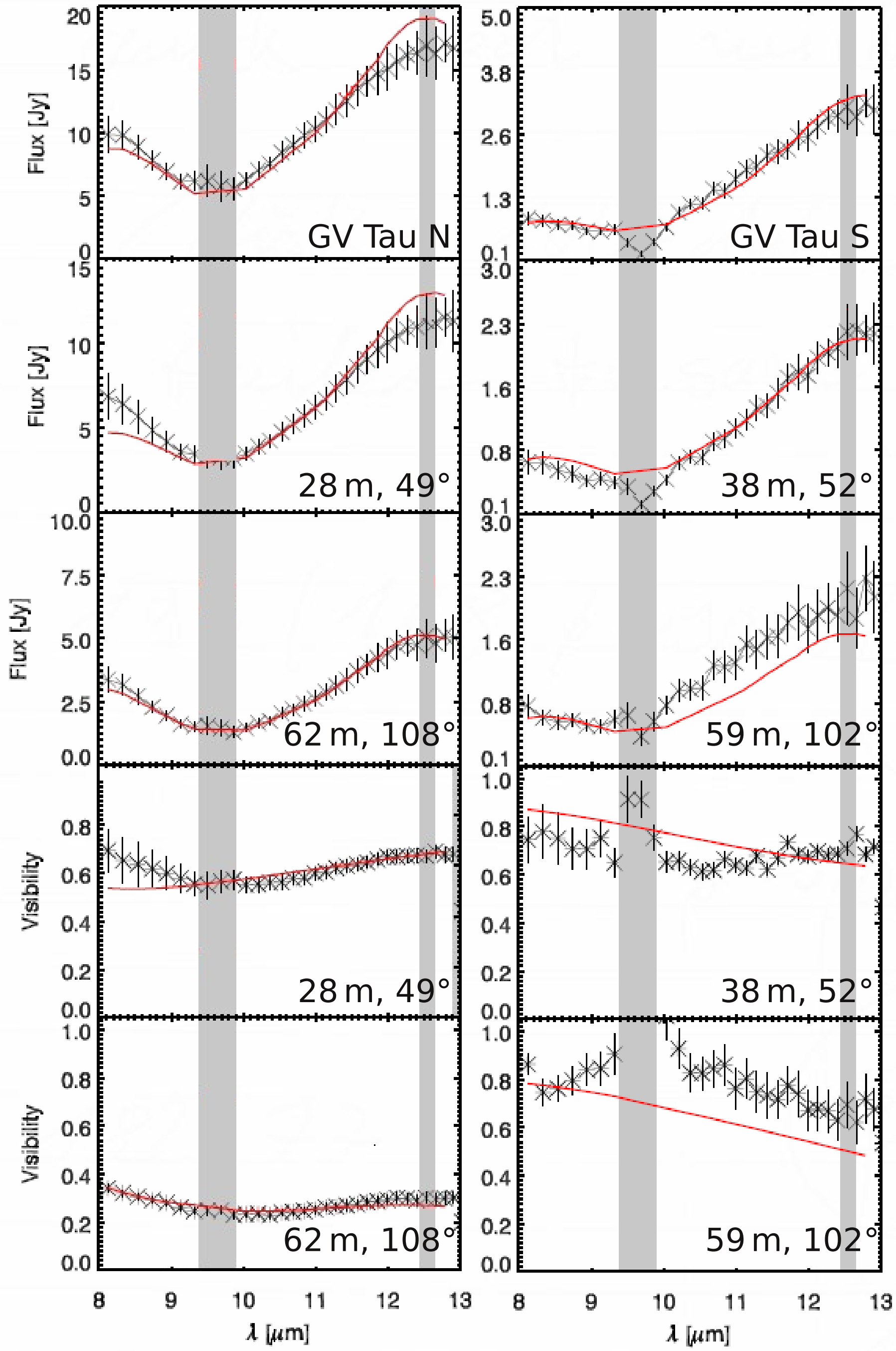
Th. Ratzka., A&A 502, 623, 2009 &
R. Köhler, A&A 482, 929, 2008

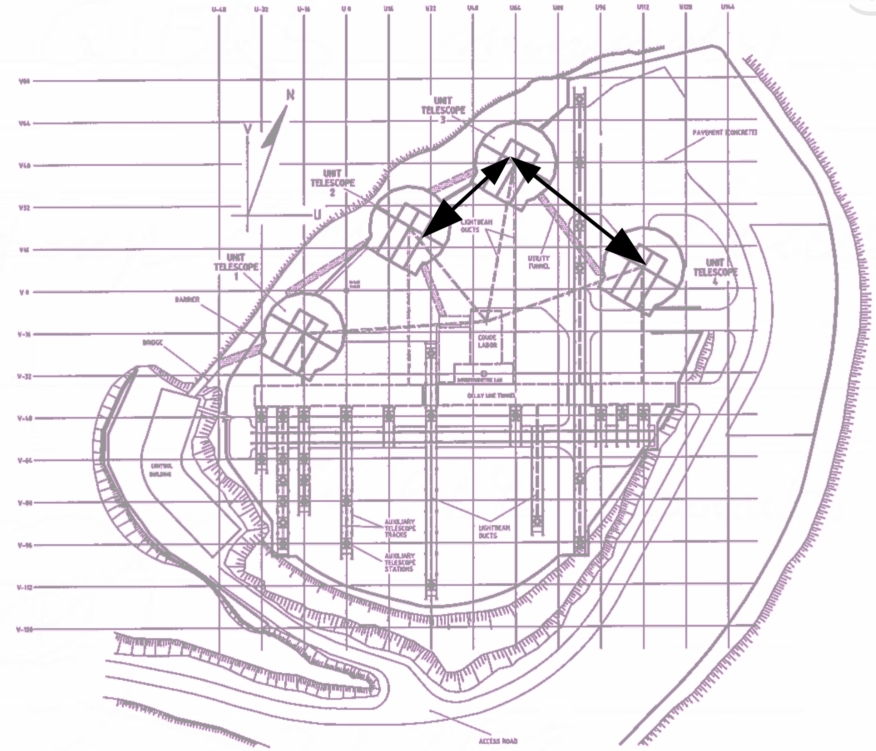
GV Tau – another IRC

- binary separated by 1.2“
- distance of ~ 140-160 pc
- variable on short timescales due to
  - inhomogeneities in the circumstellar material around the southern component?
  - variable accretion of the northern component?
- presence of a circumbinary envelope suggested



Roccatagliata et al., A&A, 534, 2011

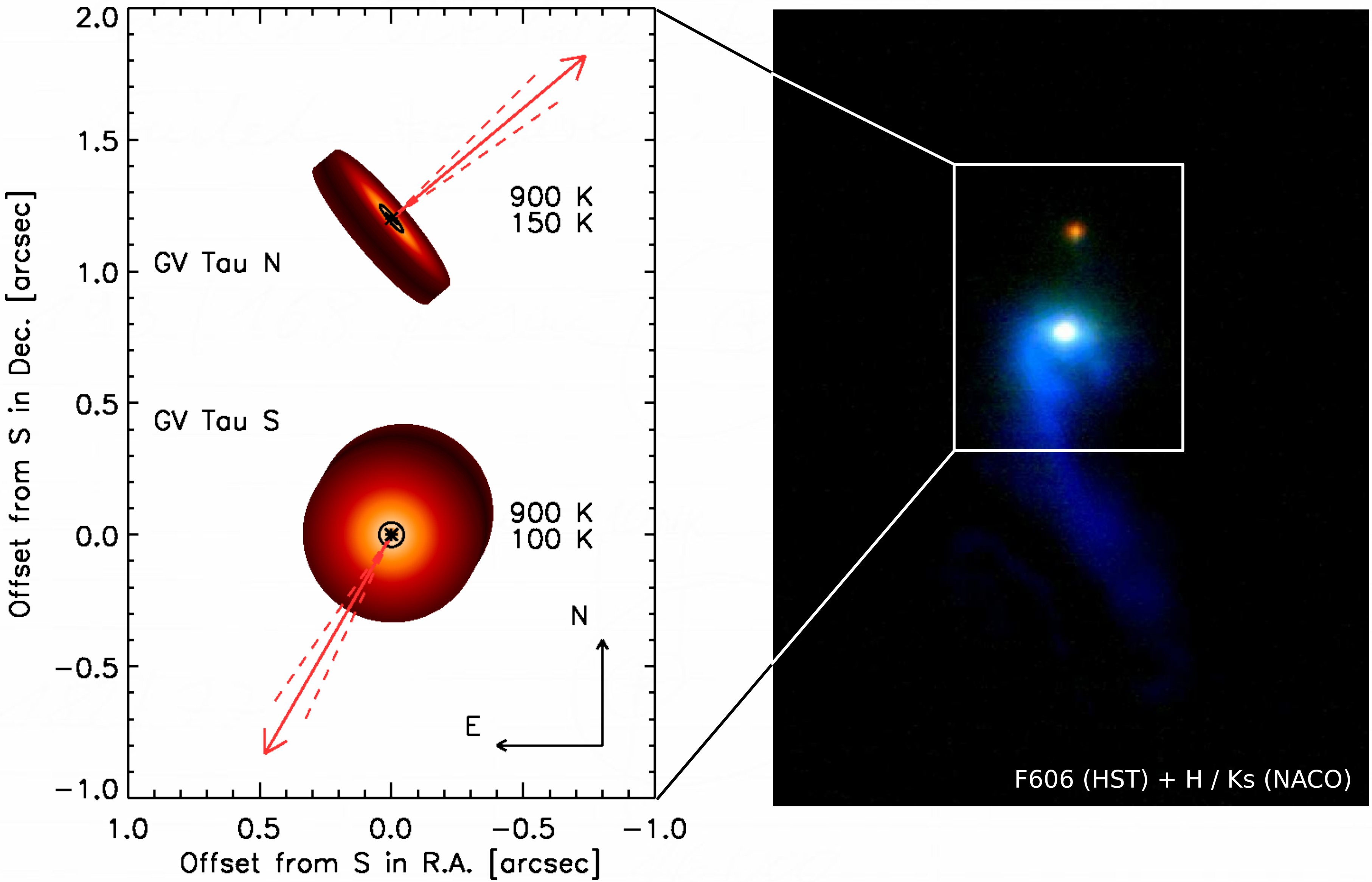




	GV Tau N	GV Tau S
r_1 [AU]	1.0 ± 0.5	1.5 ± 0.5
T_1 [K]	900 ± 300	900 ± 100
r_2 [AU]	7 ± 3	10 ± 2
T_2 [K]	100 ± 50	150 ± 50
i [deg]	**10 ± 5**	**80 ± 10**
PA [deg]	50 ± 20	50 ± 20
A_V [mag]	19 ± 4	13 ± 4

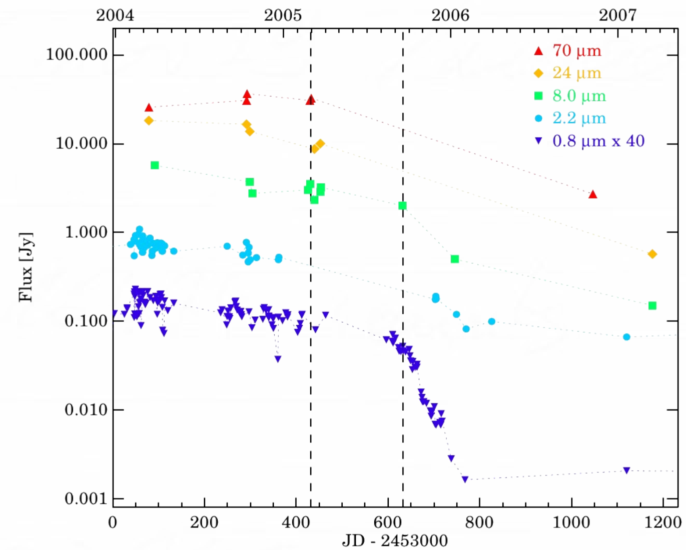
Roccatagliata et al., A&A, 534, 2011

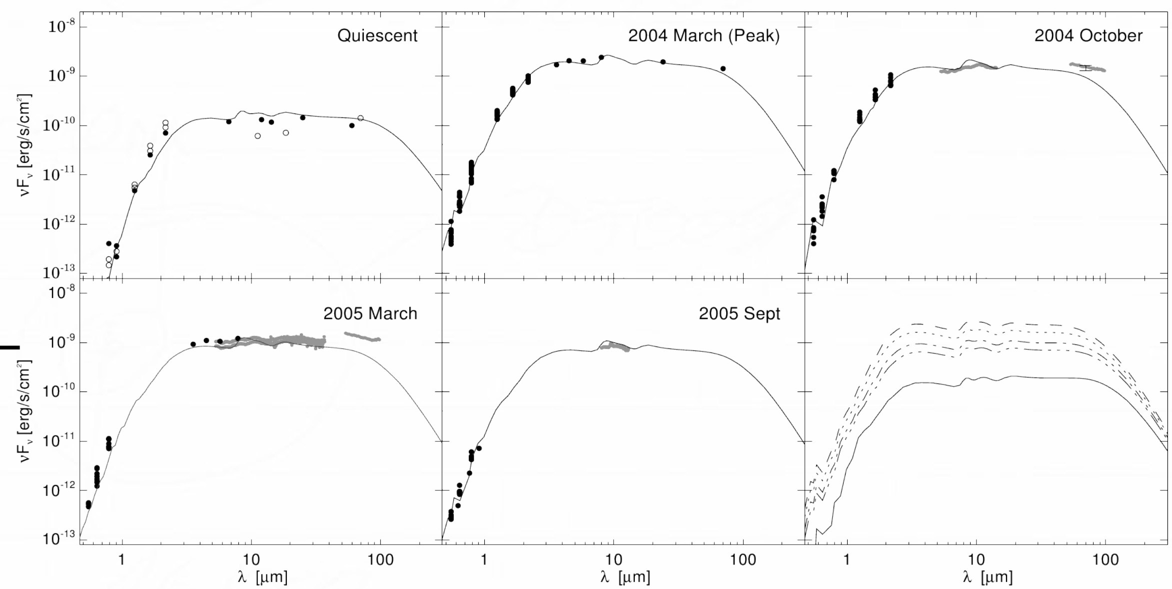
GV Tau – another IRC



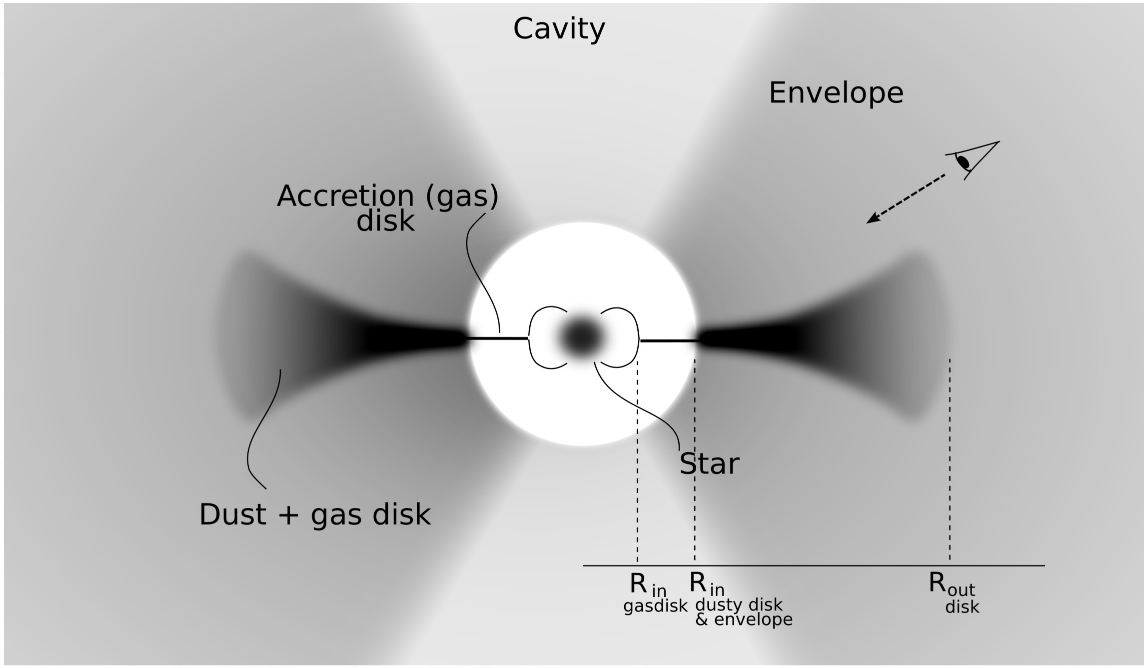
Roccatagliata et al., A&A, 534, 2011

The outburst of V1647 Ori

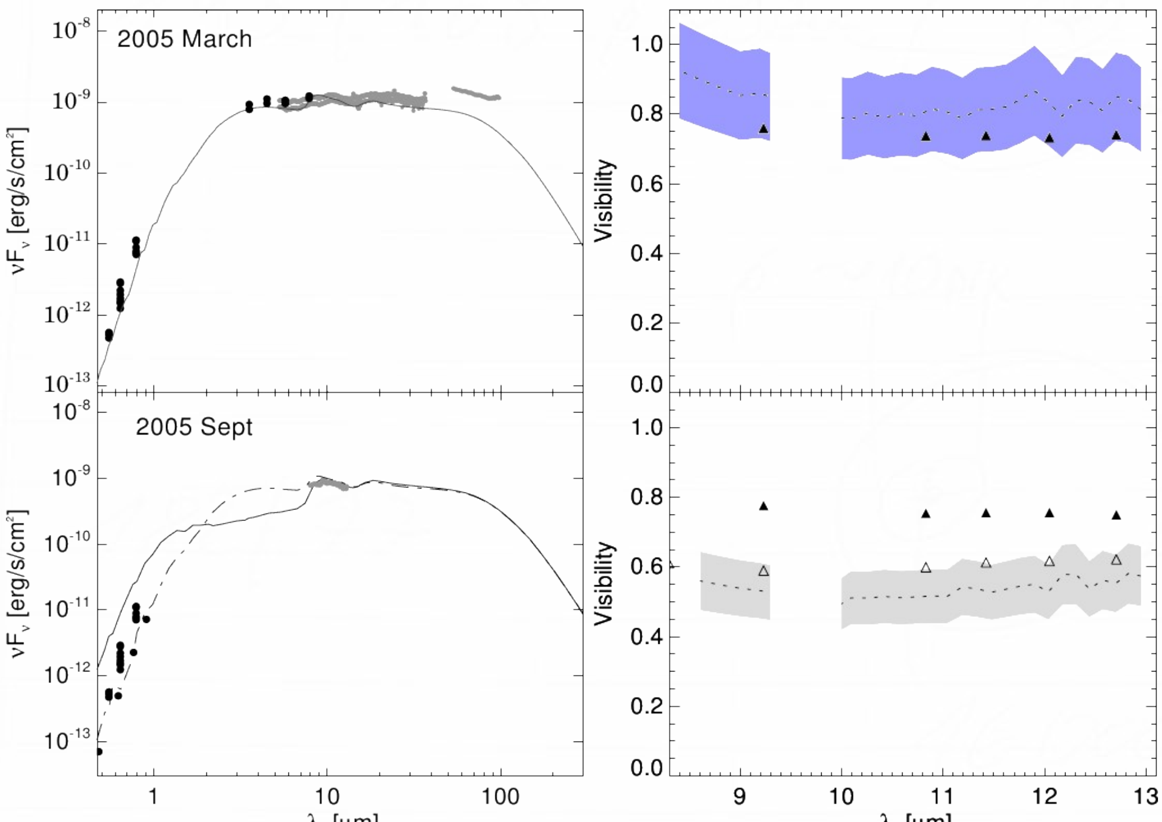


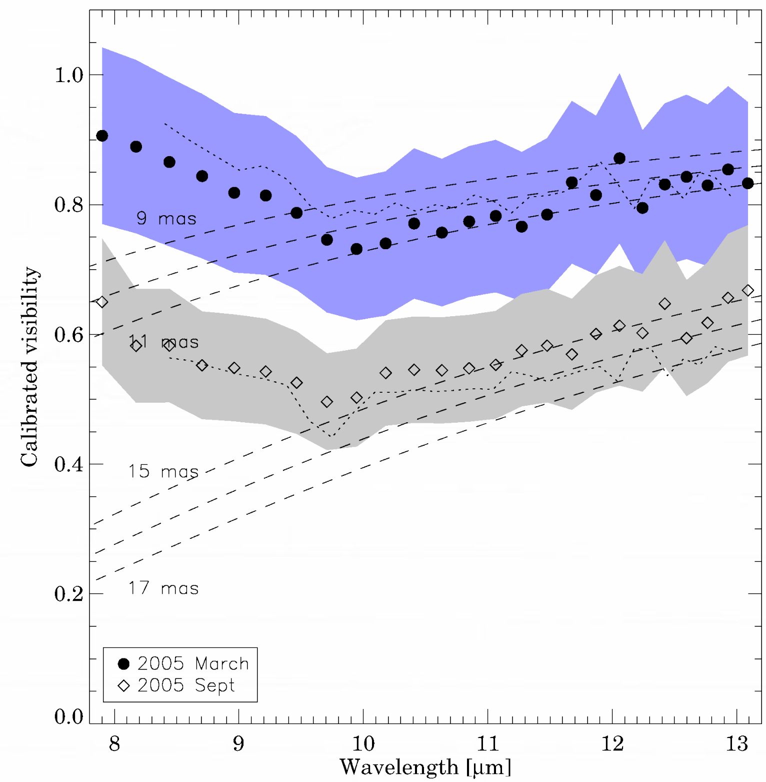


Abraham et al., A&A 449, 2006
Mosoni et al., A&A, in prep.



	dM/dt [M⊙yr⁻¹]	$R_{in,disk}$ [AU]	$R_{in,env}$ [AU]
quiesc. (2003)	$0.3{\cdot}10^{-6}$	0.4	0.4
03/2004	$7.0{\cdot}10^{-6}$	0.7	0.7
10/2004	$5.5{\cdot}10^{-6}$	0.7	0.7
03/2005	$3.0{\cdot}10^{-6}$	0.7	0.7
09/2005	$2.5{\cdot}10^{-6}$	0.7	3.0
quiesc. (2006)	$0.3{\cdot}10^{-6}$	0.4	0.4





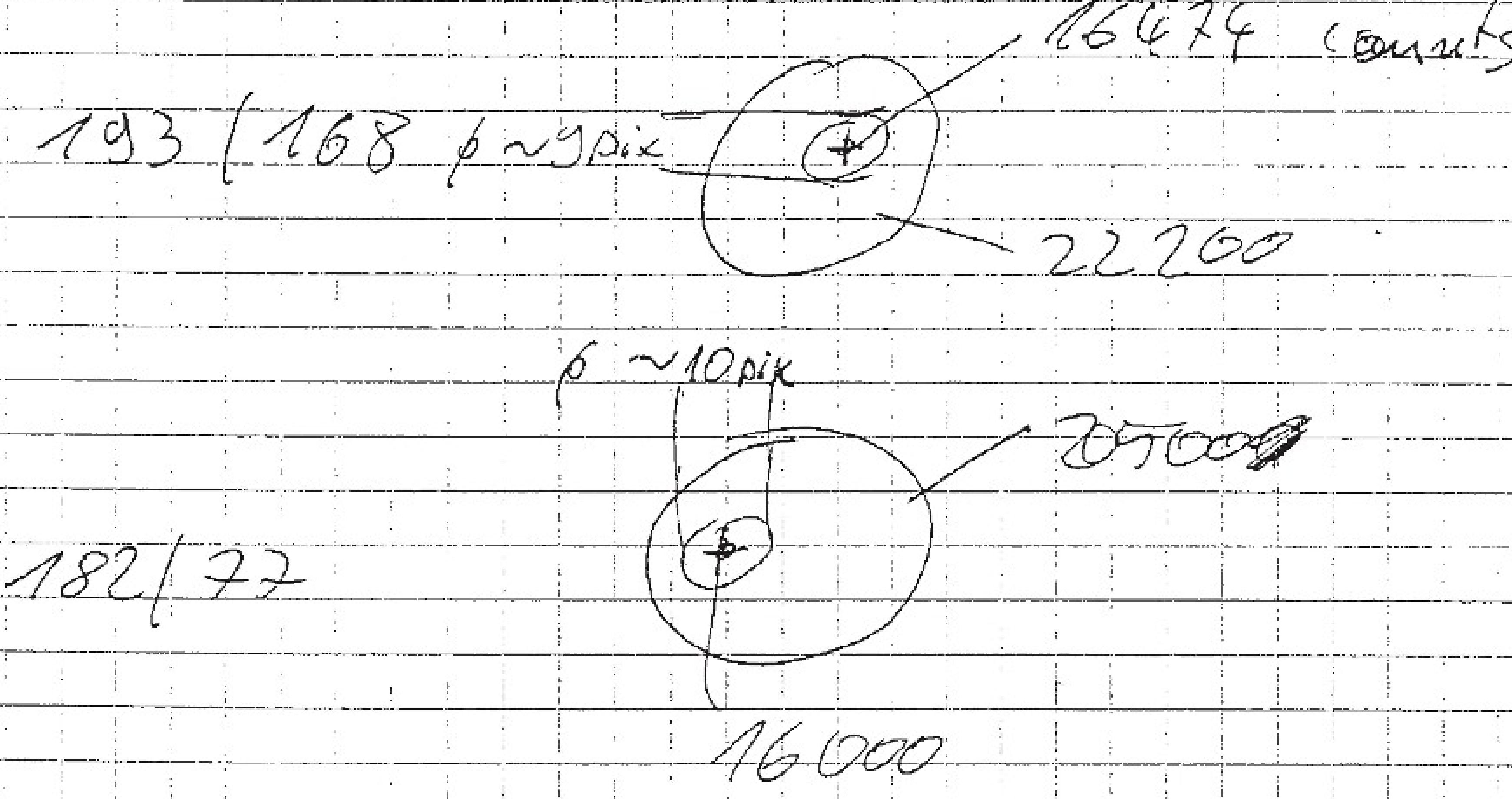
Mosoni et al., A&A, in prep.

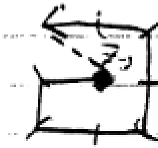
"Acta Historica" MIDI

quick check with GIERS manually

/diska/vltdata_tmp/nov29/au0000

failed to save ...





82) 12" east (SE) → T07:46:21

83) 12" north (CE) → T07:~~49:02~~ 52:35

84) 12" north (NE) → T07:54:04

85) 12" west (N) → T07:55:46

86) 12" west (NW) → T07:57:06

87) ~~On~~ source again → T07:58:35

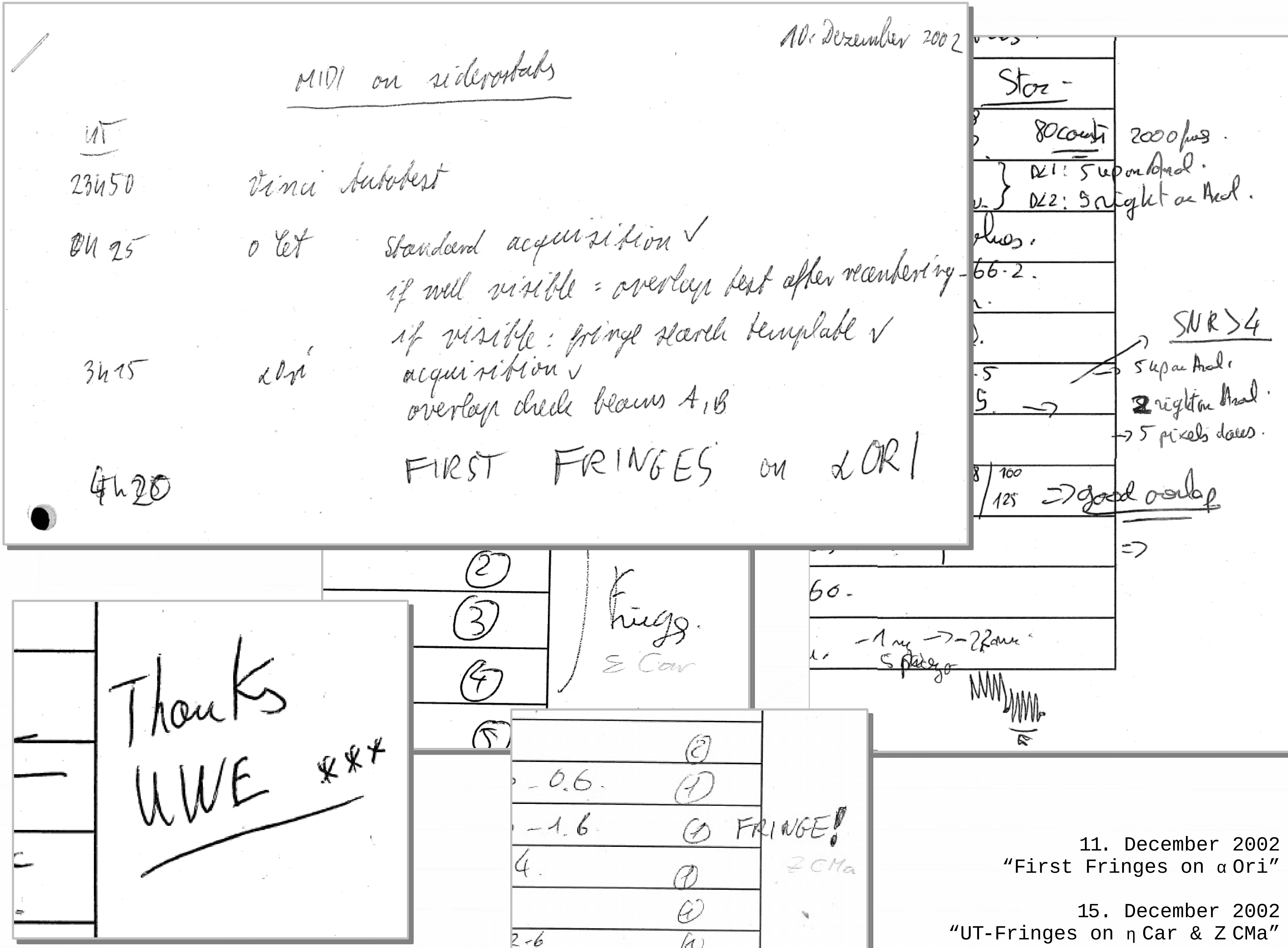
Spot at 189 | 166 !

(nominal pix-pos: 188 | 163,5)

WE SEE THE STAR !

MIDIs FIRST LIGHT

30. November 2002
“First Light on η Car”



11. December 2002
“First Fringes on α Ori”

15. December 2002
“UT-Fringes on η Car & Z CMa”